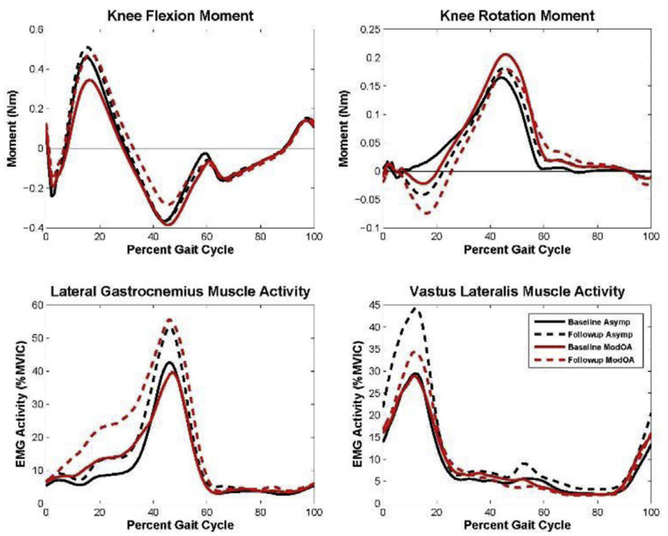
Conclusions: Despite a low incidence of radiographic knee OA progression after 3 years, there were significant joint-level biomechanics and muscular activation changes during gait. These changes may be age-related, however the change in age between sessions is small, and some changes, including the higher lateral quadriceps activity, have been related to OA severity. This suggests the potentially higher sensitivity of biomechanical/neuromuscular gait metrics in defining knee OA progression than radiographic scores. Future work will involve linking these shorter-term results to a longer-term examination of radiographic progression to examine the relative sensitivity (i.e. earlier detection of change) of gait mechanics compared to radiographic scoring.



Participant Demographics (mean +/- standard deviation)

	Asymptomatic		ModOA	
	Baseline	Follow-up	Baseline	Follow-up
MJSN (0:1:2:3:missing)	2:15:1:0:0	0:15:0:0:3	1:6:13:3:0	1:4:9:3:6
KL Score (0:1:2:3:4: missing)	0:1:14:3:0:0	0:2:13:0:0:3	0:2:8:12:1:0	0:0:6:7:4:6
BMI	27.1 (4.4)	28.2 (4.7)	29.8 (4.9)	29.8 (4.4)
Speed	1.3 (0.1)	1.3 (0.1)	1.2 (0.2)	1.3 (0.2)
Age	49.8 (6.5)	52.7 (6.6)	56.5 (6.1)	59.5 (6.1)
Time from Baseline (years)		2.9 (0.1)		2.8 (0.2)

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INFLUENCE OF WEIGHT BEARING VISUAL FEEDBACK ON MOVEMENT SYMMETRY DURING SIT TO STAND TASK IN PATIENTS WITH HIP OA

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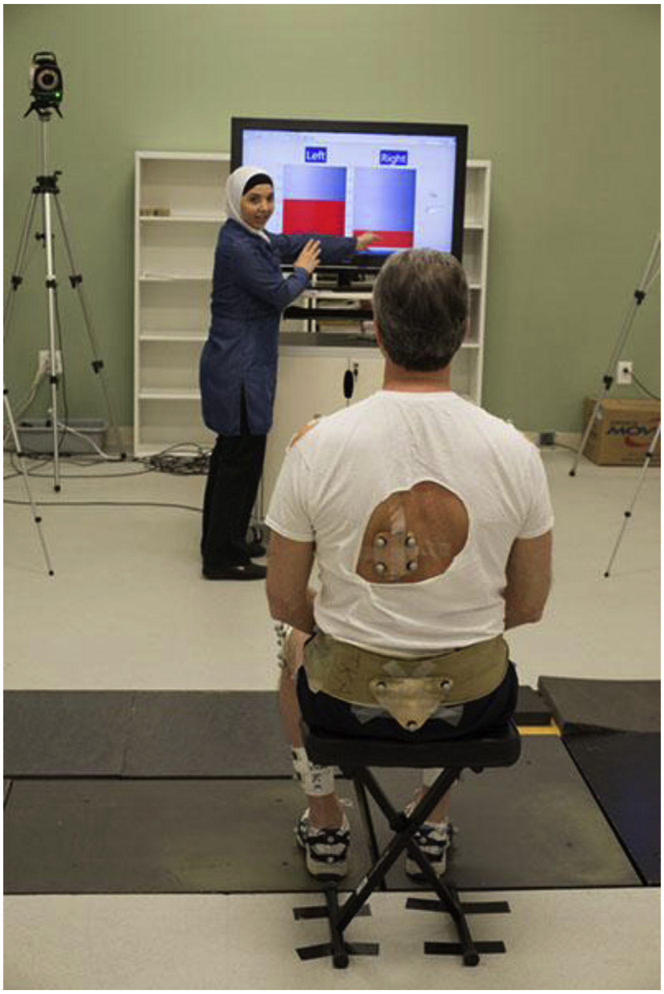
Purpose: Weight bearing asymmetry during sit to stand task is common in individuals with hip osteoarthritis (OA) and after total hip arthroplasty (THA). Individuals shift their weight to the non-affected limb and unload the affected limb. This alteration reduces hip and knee joint moments on the affected limb, and also likely reduces the muscular demand from the hip and knee extensors, while increasing the demand on the contralateral side. Including symmetry training in rehabilitation programs for patients with hip OA may normalize movement strategies during dynamic and challenging tasks. The purpose of this study was to evaluate the acute influences of real-time visual feedback of weight distribution on the interlimb joint movement symmetry during STS in individuals with end-stage hip OA. We also sought to determine whether the response to visual feedback was influenced by physical impairments, such as pain or weakness of the operated limb.

Methods: Thirty-four subjects with hip OA scheduled to undergo THA participated in this study. Pain was assessed on a 0-10 scale. Subjects underwent 3D motion analysis of STS task and completed 3 trials of STS without visual feedback ("No visual feedback" condition) followed by 3 trials with visual feedback ("visual feedback" condition). Feedback during STS was given through the use of a custom-written software program that runs on a laptop computer. The input to the feedback system was via two forceplates that transmit the force under each limb. The visual display was on a monitor in front of patient, consists of two cylinders for each limb that fill or empty based on the percentage of weight that is distributed to each limb (Figure 1).



The goal was to have the patients put equal weight between limbs during the STS task with visual feedback. No cuing for movement symmetry was provided in the "no visual feedback" condition. The symmetry index was calculated during each condition and was defined as the difference between limbs (affected - unaffected) for the vertical ground reaction force (VGRF), as well as peak hip and knee joint kinematics and kinetics in the sagittal plane. Subjects with differences between limbs for VGRF that were less than 0.05 N/BW were considered to have symmetrical movement and were excluded from the analysis. Paired tests were used to examine the change in symmetry index between two conditions and effect sizes of the change in symmetry were also evaluated. Pearson correlation analysis was used to examine the relationship between physical impairments and the magnitude of response to visual feedback.

Results: During the "no visual feedback" condition, subjects had significant interlimb differences for VGRF and joint kinetics (Figure 2).

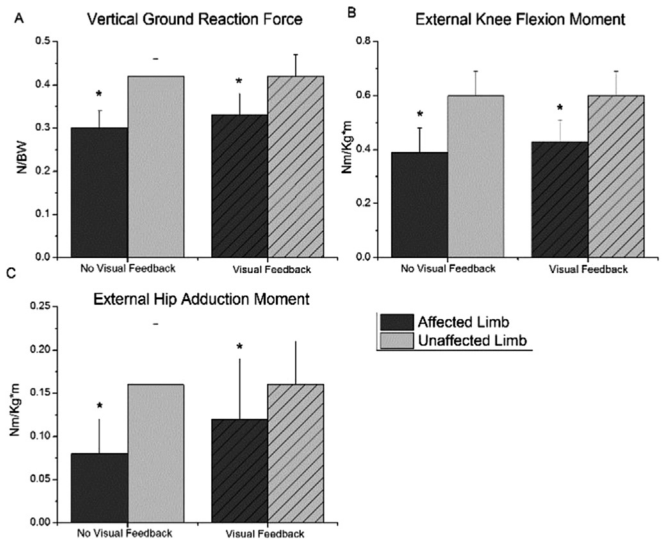


Figure 2. Subjects had significant differences between limbs for the kinetic variables of Vertical Ground Reaction Force (A), External Knee Flexion Moment (B), and External Hip Adduction Moment (C) during both the "visual feedback" and "no visual feedback" conditions. There was an improvement in movement symmetry when subjects were provided with visual feedback, which was the result of an increase in the affected side. (*) indicates significant difference from unaffected limb.

Visual feedback significantly improved the symmetry index of VGRF with a moderate effect size ($p < 0.001$, ES=0.49). There was no improvement in peak hip flexion moment symmetry ($p=0.20$), but there was significant improvement for peak knee flexion moment ($p < 0.001$, ES=0.53) and for peak hip adduction moment ($p=0.001$, ES=0.50) in the "visual feedback" condition. Hip pain of the operated limb was directly correlated with change in symmetry of peak hip flexion moment ($r=0.380$, $p=0.047$). Hip and knee strength were not related to the change in symmetry of any biomechanical variable.

Conclusions: Weight bearing feedback could have beneficial effect on movement symmetry in subjects with hip OA. On average, subjects improved movement symmetry with feedback, although subjects continued to demonstrate difference between limbs for joint kinetics and ground reaction force even in the "visual feedback" condition. Structured feedback programs that include longer sessions and training may be an effective clinical tool to improve movement patterns, but further research is warranted to determine long-term benefits of training.

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INFLUENCE OF FRONTAL PLANE KNEE ANGLE AND HIP STRENGTH ON MEDIAL KNEE JOINT LOADING DURING WALKING GAIT IN INDIVIDUALS WITH ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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Purpose: Patients with a history of knee injury have over 400% higher odds of developing knee osteoarthritis (OA). Approximately one-third of anterior cruciate ligament (ACL) injured patients that undergo surgical ACL reconstruction (ACLr) rapidly develop OA within 10 years of injury. One critical goal of post-ACLr rehabilitation is to regain lower extremity muscle strength and functional movement biomechanics to decrease disability and maintain long-term knee joint health. Greater knee varus angles during gait have been linked to greater external knee adduction moments (KAM) during gait in patients with knee OA. Excessive KAM increases medial tibiofemoral joint loading, which may increase the rate of OA progression following knee injury. Optimal hip strength may aid in proper positioning of the lower extremity during gait, potentially altering frontal plane motion and reducing KAM. Open kinetic chain hip muscle strength can easily be assessed clinically via hand held dynamometry (HHD), but it is unknown if hip muscle strength influences KAM. The purpose of this study was to determine the associations between hip strength and KAM during gait in ACLr patients. Additionally, if strength was associated with KAM we sought to determine if strength associated with KAM after accounting for variance associated with knee varus kinematics during gait.

Methods: Twenty individuals with a history of unilateral ACLr participated (70% Female, 43.8 ± 29.8 months post ACLr, 21.2 ± 2.3 years old, 73.3 ± 19.6kg, 1.7 ± 0.1m). An optoelectric motion analysis system integrated with force plates was used to acquire kinetic and kinematic gait data as subjects walked along a 6m walkway at a self-selected speed. Kinetic and kinematic data were visually inspected before being filtered and processed with in-house algorithms (LabView v 12.0). Peak KAM was determined using standard inverse dynamics calculations and extracted from the first 50% of stance phase of gait. Frontal plane knee angle, with varus represented as a positive value, was determined at initial heel strike (FrontalHS) of the stance phase of gait. We also determined the peak knee varus angle during the first 50% of stance phase (FrontalPEAK). KAM was normalized to the product of body weight and height. Hip strength using HHD was determined for: 1) hip abduction (ABD), 2) hip internal rotation (IR) and 3) hip external rotation (ER). Participants were positioned prone for measurement of IR and ER or side lying for ABD strength. The peak value of three trials were averaged and normalized to each participant's body weight. Separate Pearson product moment correlations were used to assess simple associations between 1) frontal plane knee angle and KAM and 2) hip strength and KAM. If a simple association existed between a strength variable and KAM, that strength variable was entered into separate hierarchical linear regression models for each kinematic variable. The change in R2 was determined for each regression model to determine if the strength variable explained a significant amount of variance in KAM after separately accounting for kinematic variables (FrontalHS and FrontalPEAK). Alpha level was set a priori at $p \leq 0.05$.

Results: FrontalHS ($r=0.691$, $p=0.001$), FrontalPeak ($r=0.711$, $p<0.001$) and hip ER strength ($r=0.678$, $p=0.001$) were moderately associated with KAM. We found no other significant associations between hip strength and KAM ($r=-0.15$ to 0.25). After accounting for FrontalHS, hip ER explained 12.6% ($\Delta R2 = 0.126$, $p= .03$) of the variance in the regression model predicting KAM ($R2 = 0.6$, $p< .001$). Similarly, after accounting for FrontalPeak, hip ER explained 12.2% ($\Delta R2 = 0.122$, $p= .03$) of the variance in the regression model predicting KAM ($R2 = 0.628$, $p< .001$).

Conclusions: In contrast to our hypothesis, higher hip ER strength was associated with higher KAM during gait in the involved limb of ACLr patients, even after accounting for the amount of knee varus (FrontalHS and FrontalPeak) at two points during the stance phase of gait. Open chain hip IR and ABD strength was not associated with KAM in closed-chain biomechanics during the stance phase of gait. While greater hip ER strength is associated with greater KAM, it remains unclear if stronger hip external rotators increase knee load directly or if an increase in hip ER strength is an adaptation in response to higher KAM during gait. Future research is needed to determine if changing hip ER strength in ACLr patients will positively or negatively associated with changes in KAM amplitude during gait.

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FRONTAL PLANE KINEMATICS DURING WALKING GAIT ASSOCIATE WITH INCREASED SERUM CONCENTRATION OF AGGRECAN BREAKDOWN, BUT NOT TYPE II COLLAGEN BREAKDOWN, IN PATIENTS FOLLOWING ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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Purpose: Approximately one-third of patients that undergo anterior cruciate ligament reconstruction (ACLr) will develop radiographic evidence of osteoarthritis (OA) within the first decade following surgery. Patients following ACLr experience long-term alterations in gait kinematics, which may be an important risk factor for early-onset OA. The earliest stages of OA are characterized by a disruption of the cartilage extracellular matrix, which includes a breakdown of proteoglycans (i.e., aggrecan) and type II collagen. It is unclear if knees with greater varus alignment after an ACLr are more likely to have greater disruption of the cartilage extracellular matrix. Therefore, the purpose of this study was to determine the association between in vivo frontal plane gait